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Low-complexity 3D-DWT video encoder applicable to IPTV

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ABSTRACT

3D-DWT encoders are good candidates for applications like professional video editing, IPTV video surveillance, live event IPTV broadcast, multispectral satellite imaging, HQ video delivery, etc., where a frame must be reconstructed as fast as possible. However, the main drawback of the algorithms that compute the 3D-DWT is the huge memory requirement in practical implementations. In this paper, and in order to considerably reduce the memory requirements of this kind of video encoders, we present a new 3D-DWT video encoder based on (a) the use of a novel frame-based 3D-DWT transform that avoids video sequence partitioning in Groups Of Pictures (GOP) and (b) a very fast run-length encoder. Furthermore, an exhaustive evaluation of the proposed encoder (3D-RLW) has been performed, analyzing the sensibility of the filters employed in the 3D-DWT transform and comparing the evaluation results with other video encoders in terms of R/D, coding/decoding delay and memory consumption.

1. Introduction

IPTV has been a significant driver for telecom investments for the last few years. The bandwidth requirements of video transmission make it one of the most demanding mass-market telecommunication applications to date. Transmission of a Standard Definition (SD) video stream takes several Mbit/s, whereas High Definition (HD) may reach tens of Mbit/s. This is far more than what is required for voice transmission (typically 32–64 Kbps), or even to browse the Internet [1]. As a result, IPTV has been one of the best motivations for operators to deploy higher-speed DSL (no longer 300/784 Kbps but up to 50 Mbit/s), and to consider deploying optical fiber beyond central offices to curb cabinets (FTTC), buildings and homes (FTTH) or even deploying broadband wireless technologies like WiMAX [2]. These capacity upgrades also bring much higher Internet communication speed and enable new services such as video conferencing, video surveillance, video on demand or file sharing.

Because the basic technology (IP) is the same for the Internet connection and IPTV, it enables a more fluid mix of services that can share the available bandwidth more consistently. So, the advantages and challenges of IPTV reside in the differences between existing terrestrial broadcasting TV, cable TV and satellite TV [3].

The main IPTV characteristics are

- Interactive TV support: IPTV systems have two channels which allow the service provider to distribute interactive TV applications. Live television, high definition TV (HDTV) [4], interactive games, quick searches on the Internet, etc. are some of them.
- Time shifting: This service can be used to record TV allowing the user to see these contents later.
- Personalized content: IPTV has two-way communications. This feature allows the user to indicate what he wants to see and when he wants to see it.
- It requires low bandwidth on the local loop: IPTV technology does not broadcast all channels to each end user, it allows only sending the channel requested

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3D-RLW method, we obtain a more constant quality during the whole sequence because the frames are continuously input with no need to divide the video sequence into GOPs avoiding in this manner the visual boundary effects.

Although PSNR metric ranks both 3D-RLW and H.263 in a similar way (see Table 4), the VIF metric is able to distinguish the subjective differences between them as it can be seen in Fig. 8. Again, 3D-RLW encoder has a more constant quality than H.263 during the whole video sequence, which is a nice feature when the user watches a video sequence.

5. Conclusions

This paper has presented the 3D-RLW algorithm, a fast and low-memory demanding video encoder based on the frame-by-frame 3D Wavelet transform and efficient run-length coding. The proposed scheme uses separable 1D filters implemented in the spatial domain as Daubechies 9/7F and as LeGall 5/3 in the temporal domain. It significantly reduces memory requirements while achieving faster operation, when compared to existing competing schemes. In particular, when comparing to 3D-SPIHT, H.264, x264, MPEG-2 and MPEG-4, its relative gains in terms of required memory and speed are, respectively, 25 times less memory and up to 35 times faster (for full HD); 19 times less memory (for full HD); 7 times less memory and up to 24 times faster (for full HD); 1.3 times less memory and similar coding time (for full HD); 1.2 times less memory and similar coding time (for full HD).

Regarding R/D, our proposal has a similar behavior to MPEG-2 and H.263 and slightly lower performance than MPEG-4. When compared with 3D-SPIHT, our proposal has a similar behavior for sequences with medium and high movement, but lower performance for sequences with low movement like Container. However, contrary to 3D-SPIHT, our proposal avoids the boundary effects between GOPs that appear in the regular 3D-DWT algorithm.

Although PSNR metric ranks in a similar way H.263 and 3D-RLW, the 3D-RLW encoder shows a more constant quality during the whole video sequence avoiding disturbing quality fluctuations. This is mainly due to the constant quantization applied on the 3D-RLW encoder.

In order to improve the coding efficiency, an ME/MC stage could be added. In this manner, the objects/pixels of the input video sequence will be aligned, and so, fewer frequencies would appear at the higher frequency subbands, improving the compression performance. Also, a full optimization process exploiting the parallel capabilities of modern processors (like multithreading and SIMD instructions) will make 3D-RLW even faster.

The low-memory requirements and the fast coding/decoding process makes the 3D-RLW encoder a good candidate for IPTV applications where the coding delay and memory requirements are critical for proper operation.

As future work, we pretend to add rate control functionality to the 3D-RLW encoder in order to dynamically adjust the output bit-stream to the available network bandwidth for adaptive streaming applications.

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